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ABSTRACT

This document reviews the research related to students' and teachers' anxiety related to science and the teaching of science in order to better understand the relationships between the variables that can predict this phenomenon. The research reports reviewed used either the Science State Trait Anxiety Inventory or the Science Teaching State Trait Anxiety Inventory in gathering their data. These inventories allow the researcher to change title headings within the inventory to allow the researcher to examine particular situations. Findings for the report are presented according to titles on the state anxiety scale that measure for anxiety about science and teaching science; anxiety about specific tasks; and anxiety about different science courses. The summary of the findings discusses the following variables that emerged from the analysis: (1) attitude toward science; (2) anxiety about teaching; (3) achievement; (4) examination format; (5) content courses; (6) achievement on a specific task in a content course; (7) gender; (8) confidence; (9) self efficacy; (10) demographic variables; (11) long term effects; (12) impact on teacher classroom performance; and (13) children's anxiety. Conclusions discuss the need for a model to explain how anxiety and related variables affect learning in science and for continued research in this area. A list of 28 references is included. (MDH)

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A Science Educator's and a Psychologists' Perspective on Research about Science Anxiety

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I. Introduction

This symposium provides opportunities for formal and informal discussion of concepts and ideas which may shape the development of research about anxiety and learning science and related variables. Some noteworthy ideas may not be obvious, or are so obvious they are ignored.

Because science educators can learn from examples in other fields, the general topic of anxiety about learning science is presented using an analogy from the geological sciences.

Earthquake prediction has been a topic of interest to humans since the dawn of human history. The Chinese provide an example of sustained interest, patience, and continuous study.

The first seismograph was invented in 132 A.D. by Chang Heng, a Chinese astronomer and mathematician. It was an "earthquake weathercock" where tremors activated a dragon who released a ball to sound an alarm. More than seventeen centuries later, the search of a means of warning of earthquake danger continues.

In the 1970's more than 100,000 Chinese were observing every imaginable earthquake precursor including animal behaviors. In 1975, the Chinese successfully predicted an earthquake, saving many lives. However, the following year a devastating totally unpredicted earthquake occurred. Accurate and timely earthquake prediction is still not a reality.

The quest for earthquake predictors reminds us that there may be relationships among apparently unrelated variables. The

1989 earthquake in California at Loma Prieta is an example where, accidentally, data from a military experiment may provide a clue to earthquake occurrences. Prior to the Loma Prieta earthquake naturally occurring radio waves increased substantially. To determine if this may be a precursor, instruments are now set at Parkfield, California, where earthquakes occur on "the average", every 22 years. Patience is important, as the expected earthquake is now a few years overdue.

In the geosciences it has taken a great deal of patience, many individuals, a bit of luck, and, space age technology to begin to grasp the nature of the problem of earthquake prediction. Some of the reasons experts suggest about why earthquake prediction is so difficult are:

1. Our eagerness to "know the answer" because of social pressure to predict a devastating quake, results in overestimation of predictors.

2. The way the data are collected and

3. The difficulty of obtaining a large enough data base for a long enough time period.

Perhaps, we face similar problems in our quest for understanding anxiety about learning and teaching science. Science educators seek answers to illusive questions about how we learn science. We cannot lose sight of that fact that what we call "science" is recent, "science education" still more recent and that we are investigating subjects not imagined just a century ago. Technology has provided powerful tools for problem

solving (i.e. computers), and an explosion of information. However, it is still the human mind that is the driving force formulating probing questions that may ultimately yield insights and solutions.

Science education involves problem solving. Today we are focusing on developing a perspective on how anxiety relates to learning science. This includes the long term accurate measurement of anxiety and associated variables in a variety of settings with different groups of subjects (i.e. teachers and students from elementary to university level). A hoped for outcome is to begin to understand how anxiety is related to learning and how science educators can create appropriate learning strategies and environments.

A brief synthesis of ideas which motivated early studies and some insights into the "connections" among the authors of these studies and other researchers a theme of this discussion. Hopefully it will lead to future studies with other researchers.

II. Anxiety About Science

The topics of anxiety about science, anxiety about teaching science, and understanding factors that affect learning science, have been of interest to science educators for several decades. The members of this panel, who have been involved in studies over a period of years, continue to re-examine completed studies and explore new dimensions. Hopefully, the cooperative efforts of science educators and researchers in related and even "apparently unrelated" fields working together may begin to shed light on how

anxiety relates to how one "learns" science.

Presenters at this symposium include Campbell, Czerniak, Davis and Westerback. Westerback's interest in the subject was sparked by questions from her thesis advisor about perceptions of the ability and willingness of pre-service elementary teachers to teach science. They appeared "frightened" of the subject. This translated into two consecutive full year studies of attitudes and anxiety about teaching science and two additional years of studies on anxiety. The assessment instrument for attitude was the Bratt Attitude Test (M-Bat) and anxiety was measured using the Science Teaching State-Trait Anxiety Inventory (Science Teaching STAI), Form X (Westerback 1982; 1984; Westerback and Primavera, 1988).

Czerniak's interest began with her master's and continued in her doctoral studies. Westerback and Czerniak communicated with each other in written correspondence and met at national conventions, and developed cooperative studies using the same assessment instruments, often replicating results. Likewise, Davis and Westerback met at a national convention, developed cooperative studies, and later on all three researchers conducted a symposium at AERA (Washington, D.C 1987) with Charles D. Spielberger, developer of the State-Trait Anxiety Inventory (STAI). Although Campbell and Westerback had met at various conventions, Primavera (who worked with Westerback for years) perceived a connection between anxiety studies and Campbell's work, which resulted in studies using Campbell's assessment

instrument (SaaS) and the Science STAI. Czerniak organized this symposium. Individual presentations will focus on specific issues. This overview focuses on general findings and issues.

III. Use of assessment instruments

Westerback's initial studies on attitude and anxiety about science raised questions about the selection and use of assessment instruments. At that time (1977-1979) there was no standardized, widely accepted attitude about science scale, so the Modified-Bratt Attitude Scale (M-BAT) was selected because it had been used by several science educators. There still seems to be no agreement among science educators about the existence of a well standardized attitude toward science scale. The need for such an assessment instrument is important.

Czerniak (1989) developed a scale for measuring personal and teacher efficacy and Campbell (1992) developed a Self Confidence - attribute scale (SaaS). These scales have been used in cooperative studies.

Measurement of anxiety about science can be precisely defined by the modified State-Trait Anxiety Inventory (STAI). This widely accepted standardized scale developed by Spielberger and his associates (1970, 1983, 1985) has been used in hundreds of studies by psychologist and medical researchers. Dreger, (1978) states that the STAI is one of the best standardized measures of anxiety. Using a standardized assessment instrument has the advantage of making comparisons among studies more meaningful. The development and use of standardized assessment

instruments is an important issue for researchers in science education.

The State-Trait Anxiety Inventory (STAI) is a standardized test which measures state anxiety, defined as transitory anxiety that can be influenced by training, and trait anxiety defined as relatively stable individual differences in anxiety proneness. An advantage of the STAI is that it can be adapted for use in specific situations by simply changing the titles on the state scale and carefully following directions for administration. Because the items and directions remain the same, changing titles allows researchers to take advantage of a well-standardized test to measure perceived anxiety in specific situations. The STAI is printed in many languages and is available for use by adults and children.

The adapted STAI used to measure anxiety about teaching science is called the Science Teaching STAI and the STAI adapted and used to measure feelings about science is called the Science STAI (Westerback and Primavera, 1988).

A review of research in science education relating to anxiety about science and science teaching through 1986 has been written by Westerback and Primavera (1988). Let us examine the general findings from these and more recent studies in which the Science Teaching STAI and the Science STAI have been used.

IV. The Use of the Science Teaching and Science (STAI)

A. Measuring both State and Trait Anxiety

A unifying theme of this symposium is that the researchers all used the Science Teaching or Science STAI. Westerback's early studies (1977-1979) measured only state anxiety because it was feared that asking too many questions might be tiresome for subjects and yield poor data. Consultation with Charles D. Spielberger and continued studies with hundreds of subjects indicate this is not the case. Trait anxiety, is an important variable measuring an individuals anxiety proneness. This measurement allows researchers to gage whether or not subjects are anxious about what you are measuring or is just generally anxious (Spielberger, 1985). Subsequent studies have involved the measurement of both state and trait anxiety (Westerback, 1984).

B. Changing Titles on the Science Teaching and Science STAI

One advantage of the STAI is that the modifying the titles, but keeping the items the same allows one to use this well standardized scale to measure situation specific anxiety.

State anxiety can be influenced by training and related to the specific situation in which it is measured. In order to measure state anxiety we modified the title of the scale to fit the situation in which we were working. For example when we were interested in measuring anxiety about a specific science course we titled th scale "How Do You Feel About Taking this Course?" or "How Do You Feel About Taking Earth Science?" and to measure anxiety about teaching "How Do You Feel About Teaching Science?".

This allowed subjects to illicit responses to these specific situations. On the Trait Anxiety scale Westerback used the title "How Do You Feel in General?". When the title has been modified it should be clearly noted when reporting results in the literature. Primavera and Westerback (1988) refer to the use of the State-Trait Anxiety Inventory in science education with a specific name, the Science Teaching STAI to differentiate it from the standard heading STAI Forms X and Y. For the remainder of this paper the modified form of the State-Trait Anxiety Inventory will be referred to as either the Science Teaching STAI or the Science STAI.

Charles D. Spielberger of the University of South Florida, developed the STAI and a manual for using the STAI. He answers correspondence relating to issues regarding the use of the STAI.

We would like to alert you to potential problems in using the STAI. Obtain permission and the manual for using the STAI from Consulting Psychologist Press. The modification of scale titles (with Spielberger's permission), directions given when the scale was administered and conditions under which data were collected are critical topics that should be reported. Although common sense would dictate this, experience indicates that some researchers have naively and unintentionally been unaware of the need to obtain permission, failed to score their findings in a standardized manner, or failed to provide pertinent information on conditions of data collection. It is painful to see this happen.

C. Subjects

A difficulty facing science educators, is that like earthquakes, subjects are never alike! Every group of subjects be they pre-service elementary teachers, geology students, experienced teachers, or whatever group you select to study, will be different. However, like earthquake, if you study similar groups long enough and have a large enough data base, some characteristics which typify each group become evident and some variables may be significant in all groups.

D. Research design

Research studies can only be conducted on available subjects who are usually confined to classroom or "field experience" environments. True experimental studies are few. Many studies involving anxiety about science and learning science have been quasi-experimental, descriptive or case studies. In earthquake studies -- there are no two earthquakes alike. In science education there are no two groups of subject alike. This means that a great deal of patience and a long term perspective is required to determine if the results of one study have meaning.

E. Data collection

Unless subjects take the study seriously and respond honestly to each item, the data are of no value. Therefore, data collection must be done in an environment where the subjects trust that their confidentially will not be violated. Obviously, if you plan to match data (i.e. pre and post test or conduct follow up studies), then some form of ID so that data can be

matched is essential. Social security numbers are a common ID, but some individuals feel threatened by its use. In situations where students trust their confidence will not be violated social security number or names can be used. In other situations schemes such as the use of their birthday, their mother's birthday or randomly assigned numbers can be used. Experience with randomly assigned "secret" numbers, or anything that cannot be easily remembered by the subject is that subjects forget their "secret" ID making it impossible to later match data. Every researcher needs to think about this issue when planning studies.

When the STAI, the Science Teaching STAI or the Science STAI is administered with other scales (i.e. attitude, efficacy, confidence in math and science) the STAI should always be administered first because of its volatility.

F. Data analysis

Data analysis is usually not simple. Science educators generally have a grasp of the subject, but cannot be expected to have the depth of understanding of experts in the field. Many of the research studies reported here reflect a long association with psychologists who are experts in analysis of data. This has been essential in understanding and interpreting data and provided many insights otherwise overlooked.

V. Findings

1. The Science Teaching and Science State-Trait Anxiety Inventory

The Science Teaching and Science STAI are reliable, easy to use, standardized assessment instruments which can be used for the assessment of anxiety about science teaching and learning science. Retaining all scale items, but changing scale titles allows researchers to take advantage of a standardize scale yet to tap into anxiety elicited in specific situations.

The earliest studies were done with Form X of the STAI, and later studies with Form Y. Spielberger and his associates replaced 30% of the items resulting in improved psychometric properties for both the State Anxiety and Trait Anxiety scales. (Spielberger, Gorsuch, Lushene, Vagg and Jacobs, 1983). Correlation studies indicate a high degree of relationship between the two forms for both state and trait anxiety (Westerback, 1984).

A factor analytic study of the Science Teaching STAI showed that the factor-loading pattern for pre-service elementary teachers was very similar to psychometric data available from larger studies. This result, along with high-internal consistency levels, supports the use of the modification of the STAI (Science Teaching STAI) to measure anxiety about science, etc. with preservice elementary teacher. Researches may have confidence in utilizing the instrument in science education (Sherwood and Westerback, 1983).

2. Variables Related to Anxiety as measured by the Science Teaching or Science STAI in response to modified titles:

Researchers have used the Science Teaching and Science STAI in science education over a number of years with different groups of subjects. The titles on the state anxiety scale have been modified for subjects to respond to different situations.

The title on the trait anxiety scale was changed from "Self Evaluation Questionnaire" to "How Do You Feel in General".

There are many different ways of examining these studies. In 1988 Westerback and Primavera reviewed studies conducted through 1986 presenting the studies by the different subject groups (i.e.preservice elementary teachers, inservice elementary teachers, college students). Let us now search for significant variables found in responses to titles on the state anxiety scale. Details of the studies can be found in the original publications or by contacting the researchers. We will present highlights.

VI. Important Variables Found in Response to Different Titles

A. Studies Using Titles for Measuring Anxiety About Teaching and Teaching Science:

1. "How Do You Feel About Teaching Science"

(a) attitude

-- using Modified Bratt Attitude Scale
-- Pre-service teacher's attitude toward science and anxiety about teaching science were changed in a positive direction during a sequence of science content courses. Students with reduced anxiety levels tended to have positive attitudes. (Westerback, 1982)

(b) Self-Efficacy

-- using Czerniak Efficacy scale
-- Personal and teacher efficacy were measured by the scale developed by Czerniak. Personal efficacy is a measure of belief that you personally have the ability to affect student learning in science. Teachers' efficacy is a measure of your belief that any teacher can affect student learning in science in spite of all other factors such as home life, societal factors, etc. (Czerniak, personal communication, June 4, 1991) and paper presented in this symposia (Czerniak, 1992).

In a pilot study preservice elementary teachers high in personal efficacy had low state anxiety when asked about learning science (-.6414, N=16, p.007) (Westerback and Primavera, 1992 unpublished).

(c) Demographic variables (Westerback, 1982)

Preservice elementary teachers were asked about completed courses:
(1) number of high school science courses
(2) level of enjoyment of high school science
(3) number of college science courses
(4) level of enjoyment of college science courses
(5) number of high school math courses
(6) level of enjoyment of high school math courses
(7) number of terms of college math courses
(8) level of enjoyment of college math courses

-- None of the variables were significantly related to attitude toward science or anxiety about teaching science for the initial administration of the M-BAT and STAI. However, a closer examination of the data shows that students with positive attitudes and low anxiety had a 3:1 like/dislike ratio for enjoyment of math.

-- Czerniak (1989, 1990) states that students who took more science content courses and experienced success with science content courses had lower anxiety toward teaching science than their counterparts.

Prior experience
-- Pre-service elementary teachers were asked to respond to experiences they felt related to their attitude toward science. Initially students who reported negative background influences had slightly higher anxiety scores than students who reported positive influences. The difference was not significant and was diminished before the course ended. (Westerback, 1982)

(d) Course Sequence for Science Content Courses

-- Preservice elementary teachers taking a sequence of science content courses could begin the sequence with an earth science and biology science segment or with a physical science segment (astronomy, chemistry and physics). Anxiety reduction patterns were similar regardless of the order the courses were taken. (Westerback, 1984)

(e) Instruction by Different Teachers

-- Ten different faculty taught science during the four year period during which studies were conducted with preservice elementary teachers in science content courses. There was no difference in overall anxiety reduction of students anxiety about teaching science in classes conducted by different teachers. In the two cases incidents where anxiety levels were temporarily elevated the following teacher behaviors were noted: (1) the teacher graded on a "curve", and (2) rote memorization was stressed (Westerback, 1984). Perhaps the overall course structure: teachers in the same disciplines planning lessons together, using the same teaching materials and exams accounts for the consistent patterns of anxiety reductions among students of different teachers.

(f) Anxiety Reduction after the First Exam

-- Anxiety levels for preservice elementary teachers taken after the first examination were significantly reduced. Most students were satisfied with their grades, and this experience is reflected in their anxiety scores (Westerback, 1984).

(g) Lasting effect

-- After completing science content courses both attitude toward science and anxiety about teaching science continued to change in a positive direction during the "student teaching experience" (Westerback, 1982).

2."How Do You Feel About Teaching Earth Science with Your Present Knowledge?

(a) anxiety levels

-- High initial state anxiety levels of experienced elementary teachers were changed in a positive direction during science instruction

during an NSF program. The reduction of state anxiety was consistent with comments made to staff members and school district supervisors and administrators. (Westerback and Long, 1990).

(b) teaching science 5 years later

-- Five years later some of teachers were now teaching math, in supervisory positions, or no longer teaching (deceased). The fifty percent that responded who were still teaching elementary science all indicated that: they still remember many of the things learned in earth science, enjoy teaching students about earth science, believe their students enjoy learning about earth science, still have former students who talk to them about learning science, are recognized by their colleagues as interested in science, have worked with colleagues to help them improve their science teaching, have been given time to do workshops on science, been recognized and encouraged by their administrators and would like to continue to share their experiences with others and, would consider presenting a paper at professional meetings like the National Science Teacher's Association (Westerback, unpublished 1990).

(c) Achievement, examination format

-- As a group. experienced elementary teacher's state anxiety was reduced, and achievement as measured by grades was almost uniformly high. As these were adult students returning to college for the first time after years, the initial examination was upsetting probably due to high self-imposed expectations. Change in examination formats and frequent untimed "mini" exams which emphasized understanding and analysis may have contributed to anxiety reduction (Westerback and Long, 1990).

3. Simultaneous Administration of:
"How Do You Feel About Teaching?" and
"How Do You Feel About Teaching Elementary Science?"

(a) Anxiety about teaching versus anxiety about teaching science

-- On the same administration of the Science Teaching STAI subjects were asked their feelings toward teaching and toward teaching science. Results indicate that anxiety toward teaching is a component of anxiety toward teaching science

(Czerniak and Chairelott, 1986; Czerniak, 1989).

(b) Teacher Attitudes

-- Czerniak and Chiarelott (1986) used the M-BAT attitude scale and found that experienced teachers with low anxiety levels about science teaching had positive attitudes.

(c) Attributes of Children

Children's Anxiety with Science Anxiety Questionnaire

-- Czerniak (1983) developed an assessment instrument named the Science Anxiety Questionnaire (SAQ). Factor analysis of the SAQ indicates the presence of four factors: (a) direct, physical application of scientific principles; (b) testing; (c) performance in front of other while doing things related to science; and (d) general application of scientific principles. Chiarelott and Czerniak (1986) found no relationship between teacher anxiety as measured by the Science Teaching STAI and children's anxiety measured with the SAQ.

(d) Gender, Grade Level and Achievement

Czerniak and Chiarelott (1985) examined the relationships among gender, grade levels, science anxiety and achievement.
-- Using the Science Anxiety Questionnaire for the examination of the following four variables (1) testing situations (2) laboratory/experiment situations, (3) classroom/lecture situations, and (4) science related situations, they found differences for overall science anxiety for all variables but one, the general application of scientific principles.

-- Differences on science anxiety did exist for grade levels. Students in the fourth grade were more anxious than those in the eight grade for overall science anxiety, and fourth grade students were more anxious than eighth grade students on two variables -- testing and direct application of scientific principles.

-- Achievement as measured by the Comprehensive Test of Basic Skills was inversely related to science anxiety scores. Czerniak and Chiarelott (1985) found that
(1) Feelings, particularly anxiety toward science and science related topics, are significantly gender-related. Females being more anxious than males.
(2) Females at grade four already display more

anxiety toward science than males.

(3) Anxiety did not increase with grade level.

(4) High levels of science anxiety correlate with low levels of achievement.

(e) Self-Efficacy

-- Science teaching anxiety and science teaching efficacy are related. The higher a teacher's anxiety toward teaching science, the lower the teacher's science teaching efficacy. The greater the teacher's perception of personal control of science teaching the lower the anxiety (Czerniak, 1989)

-- Czerniak (1992) demonstrated that preservice teachers who are anxious about teaching science appear more concerned with classroom management and student control, while less anxious teachers are more concerned about student learning.

(f) Instructional methods

-- Low science teaching anxiety correlated with higher number of instructional methods learned (Czerniak, 1989).

(g) Confidence

-- Low confidence in using a variety of instructional methods is related to high science teaching anxiety. (Czerniak, 1989).

-- Westerback and Primavera, are using the SaaS developed by Campbell (1992) to explore relationships among math and science self-concept at the Science STAI

B. Studies using titles to measure anxiety about specific tasks

1."How Do You Feel Teaching Students to Identify Minerals and Rocks?"

-- Preservice elementary teachers were initially very anxious about this task. The anxiety was reduced during instruction (Westerback, Gonzalez and Primavera, 1985)

2. "How Do You Feel About Identifying Minerals and Rocks?"

(a) the task of identification

-- As a group, students taking college geology courses were not anxious about the task of identifying minerals and rocks. However, when the sample was split into two groups (above and below the mean laboratory examination grade) students in the above mean group had lower anxiety (Westerback, Gonzalez, & Primavera, 1985).

(b) gender

-- There was no significant differences between male and female students taking geology courses on anxiety about characteristics for identifying minerals and rocks (Westerback, Gonzalez and Primavera, 1985)

3."How Do You feel About Teaching Your Students to Do Scientific Experiments?"

(a) "hands on" activity

-- Goldsmith, 1986) investigated the structure of teaching units and Type A Behavior. In his study the students in a science methods course were divided into an experimental and control group. The experimental group had teaching units of eight "hands on" activities to be taught through process skills while the control group had usual classroom instruction. Goldsmith found that anxiety was reduced in the experimental group.

(b) Type A Behavior

-- Goldsmith (1986) found no relation to type A behavior as measured with the Jenkins Activity Survey and anxiety about teaching others to do experiments. As there were only 19 students in the experimental group and 18 in the control group is it possible that the results would be different with a larger sample?

C. Studies using Science STAI titles for different science courses:

The studies reported under these titles were conducted with students taking required college courses. In the first study only the initial anxiety levels of all students was measured. All other studies involved pre and post testing of anxiety levels.

1. "How Do You Feel About Taking This Course?

Anxiety levels for 778 students taking required science courses in the Departments of Biology, Chemistry, Geology-Geography, Physics and Psychology (Westerback, 1986)

(a) Initial scores

-- All of the initial means for state and trait anxiety were remarkably consistent with means reported by Spielberger, Gorsuch, Lushene, Vagg and Jacobs (1983) for college males and females under normal conditions.
-- There was no significant differences between state anxiety scores for students taking Biology, Chemistry, Earth Science/Geology and Physics.

(b) Gender

-- There were no significant difference between the state anxiety scores of males and females taking the same course except in Psychology where the state anxiety scores of females were significantly higher than the males.
-- Comparison of state scores of males indicated that there were no significant differences among state anxiety scores of males among any of the courses.
-- Comparison of state scores among females indicated there were no significant differences among state anxiety scores of females in chemistry, earth science/geology and physics courses. The scores of females in biology and psychology courses were higher. The difference was significant between females in earth science/geology and biology; and between females in physics and psychology. It appears that females taking physical science (chemistry, physics and earth science/geology) had lower anxiety that females in life sciences (biology) and psychology). This requires further investigation.

Anxiety levels for students in college geology and earth science.

(a) Initial anxiety levels

-- Initial state anxiety levels were not elevated for students electing to fulfill their science requirements in either geology or earth science (Westerback, Gonzalez and Primavera, 1984).

(b) Achievement

-- At the end of the course, when students were divided into grade groups above and below the mean it was found

that students with high grades had low anxiety and vice versa (Westerback, Gonzalez and Primavera, 1984). This inverse relationship between grades and anxiety supports the work of psychologists.

(c) Gender

-- There was no difference in state anxiety levels of males and female students taking required college geology or earth science courses. (Westerback, Gonzalez and Primavera, 1984, 1985).

(d) Positive and negative influences

-- When given the opportunity to report prior positive or negative experiences in science students taking geology or earth science reported more positive than negative influences (Westerback, Gonzalez and Primavera, 1984).

(e) Enjoyment of high school science and math

-- College students viewed their high school math and science experiences as more enjoyable than not. (Westerback, Gonzalez and Primavera, 1984).

(f) Elect more courses

-- There was a significant difference between students with high grades and students with low grades and desire to elect additional science courses. Students with high grades planned to elect more courses (Westerback, Gonzalez and Primavera, 1984).

2. "How Do You Feel About Chemistry?"

(a) Anxiety levels

-- Davis (November 13, 1986 personal communication; 1987) used the Science STAI to measure anxiety among college students enrolled in an introductory chemistry lecture course in a mid-western four-year institution. He found that the anxiety for chemistry between those students who are successful and those students who are less successful become significantly different as a function of time spent in the course. The differences can be attributed to reduction in anxiety for chemistry by the more successful students.

(b) Gender

-- Davis found no significant difference in anxiety about chemistry between males and females (personal communication, November 13, 1986).
-- Davis (1990 personal communication) found that anxiety for chemistry between male and female students disappears as progression through the course occurs.
-- No gender differences at the end of the course, but there were gender differences at the beginning.

(c) Achievement

-- As the course continued, by the 13th class after unit on electron configuration, VSEPR, Valence Bond Theory and hybrid orbitals, students with higher grades were less anxious (Davis, 1987).

3. "How Do You Feel About Learning Science?"

Self Confidence

-- Students taking required courses in geology and earth science were given the Self Confidence Attribute Scale developed by Campbell and asked: father's occupation, mother's occupation, college major, grade point average, grades last year, grades in science, grades in math, year in college, SAT verbal score, SAT quantitative score, SAT total score, parents living, parents living with you, where were you born, where was father born, where was your mother born, father's education, mother's education, ethnic group, if Asian, and age.
In this pilot study **achievement** as indicated by self reported grades in science correlated significantly with state anxiety. There was no correlation with trait Anxiety (N-66, -.4119, p=.001, Westerback and Primavera, 1992 unpublished).

4. "Student Survey"

-- Yurkowicz, W. (1988) examined the relationship among teacher behaviors, science anxiety and success in science in 1622 science students from 86 secondary classes (grades 9-12) in upstate New York public schools, including rural, suburban and city systems.

(a) Teacher anxiety related behaviors

-- Using an author constructed instrument Yurkowicz examined the following behaviors"

(1) elitism
(2) expectation clarity
(3) remedial opportunity
(4) instructional difficulty
(5) study support

He indicates that student perceptions of teacher behaviors were related to pupil science anxiety.

(b) Achievement

-- Yurkowicz reports that anxiety was negatively correlated with achievement.

(c) Other variables

-- Yurkowicz reported that other demographics, sex, science subject, grade level, Regents or non Regents course and ability produced little or not effect on the relationships.

5. STAI in other languages

Hebrew Version using standard title "Self Evaluation Questionnaire"

Examination Type, Anxiety and Achievement

--Zoller and Ben-Chaim (1988) found that freshman to senior prospective biology teacher's correlated with types of examination, with a tendency toward somewhat higher anxiety for females. The preferred types of examination reduce test anxiety significantly, and result in higher grades accordingly. The reduction of anxiety and the improvement in achievements as a function of the examination type are far more significant for low achievers compared with medium and high achievers. The preferred examinations emphasized understanding and analyzing rather than memorization, permitted the use of relevant material during examinations, and that the time duration was practically unlimited.

VII. Summary and Discussion

Geologist re-examine the rock record for past earthquakes to ultimately predict future earthquakes. Likewise, science educators can learn from re-examining studies to plan studies which will substantiate previous work and yield new information.

In this review old and new, published and unpublished studies using the Science Teaching and Science STAI, have been grouped by responses to titles on the Science Teaching STAI or the Science STAI. Let us see if some variables are consistently related to state anxiety regardless of scale titles.

(A) Attitude toward science

Positive **attitudes toward science** is related to low state anxiety about science in preservice teachers.(Westerback, 1982 Czerniak and Chiarelott, 1986).

(B) Anxiety about teaching

Anxiety about teaching is a component of **anxiety toward teaching science** (Czerniak, 1989).

(C) Achievement

In every study where **achievement** and anxiety could be studied high achievement was related to low state anxiety and vice versa (Czerniak and Chiarelott, 1985; Westerback, Gonzalez and Primavera, 1985; Westerback, 1984; Zoller and Ben-Chaim,1988;

In a pilot study using the SaaS developed by Campbell, self reported grades in science correlated with state anxiety on the Science STAI for students taking earth science and geology courses. Students with high self reported grades had low state

anxiety and vice versa. Grades in science were more closely related to state-anxiety than grade point average, grades in mathematics or S.A.T. scores (Westerback and Primavera, 1992, unpublished).

College students taking required courses with high achievement planned to elect additional science courses while their less successful counterparts did not (Westerback, Gonzalez and Primavera, 1984).

(D) Examination format

Because achievement is measured by grades on examinations, studies concerned about the content, structure and administration of examinations are useful. Zoller and Ben-Chaim (1988), found that examination format or type appears to be related to anxiety in pre-service biology teachers. Students preferred examination emphasizing understanding and analyzing, the use of relevant materials during examinations and unlimited examination time including take home examinations. Westerback and Long (1990) found that "mini" examination which emphasized understanding and analysis may contribute to anxiety reduction in experienced elementary teachers.

Apparently when students perceive success (as measured by grades) anxiety reduction occurs. Westerback (1984) found a large significant reduction in anxiety in pre-service elementary teachers after the first examination. Therefore, giving an untimed based on understanding early in the semester is recommended.

(E) Content courses

Content knowledge appears to be related to anxiety about teaching science, although the relationship is not always clear cut (Czerniak, 1989). Preservice and inservice teachers enrolled in science content courses designed for them showed reduced anxiety after instruction (Westerback, 1982, 1984; Westerback and Long, 1990). For preservice teachers these patterns were consistent in four years of studies (Westerback, 1984). During this time period it was noted that when a number of instructors worked together in a program of science content courses designed for elementary teachers, differences in anxiety reduction among students of those instructors was not significant overall. This implies that uniform course structure (planning, using the same materials and examinations, and communicating with each other) may be important. In two cases specific anxiety provoking instructor behaviors could be identified (grading on a curve or rote memorization) which were apparently reflected in elevated anxiety levels of their students. When the behaviors stopped anxiety levels dropped. (Westerback, 1984).

The **order that science content courses are taken** by preservice teachers (physical science or life sciences first) did not make any difference in anxiety reduction patterns. The greatest reduction occurs in the first course regardless of subject matter (Westerback, 1984).

Achievement, examination type and subject matter (content) are obviously linked. Achievement is measured by grades on

examinations. Educators need to clearly report what type of information was required of the student on examinations and how students reacted (satisfied or dissatisfied) because the content, structure, administration and feedback from students about examinations may be reflected in anxiety levels.

(F) Achievement on a specific task in a content course

If students perceive a particular task as difficult, i.e., identifying mineral and rocks, balancing equations, understanding density, etc. and they learn to be successful at this task state anxiety about that task can be reduced (Westerback, Gonzalez and Primavera, 1985; Davis, 1987).

(G) Gender

Although it is commonly stated that females are more anxious about science than males, gender differences for anxiety about science are not well documented for children and adults in many different settings. Studies indicate that they exist for children. Gender differences were found for elementary students with fourth grade students more anxious than eighth grade students, and females were more anxious than males (Czerniak and Chairelott, (1985). The predominance of female subjects made examination of gender difference impossible for studies conducted with preservice and inservice elementary teachers.

The common assumption that females are more anxious than males about science is not supported by studies by studies using the Science STAI with college students. Because both male and female college students must take science courses to fulfill

their science requirements, gender differences can be examined for this group. Initial anxiety scores of students taking required science courses in biology, chemistry, geology-geography, physics and psychology were not significantly except for psychology where females were significantly higher than males (Westerback, 1986). Pre and post test data indicate gender differences were not significant for anxiety about taking earth science and geology courses (Westerback, Gonzalez and Primavera, 1984;) or chemistry (Davis, 1987). We cannot assume that anxiety levels of female and male subjects are the same for all academic disciplines or every situation.

Davis (1987) observed significant gender differences at the beginning of the chemistry course which disappeared during instruction. Could success be a factor in closing the gap? In geology females had lower anxiety levels and higher achievement than males, but the difference was not significant. (Westerback, Gonzalez, and Primavera, 1984). However, the trend warrants further investigation.

Campbell (1992) has identified hundreds of variables relating to gender equity issues.

(H) Confidence

Preservice elementary teachers who had high confidence in using a variety of instructional methods had low anxiety about teaching science (Czerniak, 1989).

It would be helpful to have a large sample and determine if general self confidence, confidence in mathematics and confidence

in science are related to anxiety about science.

(I) Self Efficacy)

High science teacher efficacy is related to low anxiety about teaching science (Czerniak, 1989). This is manifested in preservice teacher behaviors. Less anxious individuals are less concerned about classroom management, behavior management and control and more concerned about learning (Czerniak, 1992).

(J) Demographic variables

One expects the number of science and mathematics courses and the enjoyment of those courses to be related to anxiety. In studies done in the late 1970's, this was not the case for preservice teachers (Westerback, 1982). However, closer examination of data from students with positive attitude and low anxiety revealed a 3:1 like/dislike ratio for enjoyment of mathematics (Westerback, 1982). In this same students, negative prior experience, measured in relation to attitude toward science, resulted in slightly elevated, but not significant, anxiety levels which diminished during instruction (Westerback, 1982).

(K) Long term effects

It is difficult to assess if anxiety reduction has a lasting effect. Much more "follow up" research needs to be done. Westerback (1982) found that attitude and anxiety levels of students (who completed science content courses) continued to change in a positive direction after "student teaching". Westerback and Long (1990) found that 5 years after an NSF

science content course in earth science teachers reported they still remember many of the things learned in earth science, enjoy teaching students about earth science and believe their students enjoy learning about earth science.

(L) Impact on teacher classroom performance
Self-efficacy, teacher education variables and instructional strategies

The manifestation of anxiety in the classroom is an area of major concern. Czerniak (1989) found that the higher number of **instructional methods** learned is related to low teacher anxiety, and also low teaching anxiety is related to **high confidence in using a variety of instructional methods.** The relationships among **science teaching anxiety, self-efficacy, teacher education variables and instructional strategies** investigated by Czerniak indicate that high **science teacher efficacy** is related to low anxiety. In a pilot study, using the same assessment instruments, Westerback and Primavera (1992 unpublished) also found this relationship. Recently Czerniak (1992) demonstrates a relationship between self-efficacy and teacher behavior. Pre-service teachers who are anxious about teaching science are concerned about classroom management, behavior management and student control, while their less anxious counterparts are more concerned about student learning. Furthermore, these anxious pre-service teachers tend to blame failures on factors other than their own behaviors, while their counterparts are more willing to explain success and failure on their own actions.

The way teachers are taught can also be reflected in anxiety

scores. Goldsmith (1987) found that anxiety was reduced in when preservice teachers were taught using "hands on" activities.

(M) Children's anxiety

Czerniak (1986) investigated attributes of children, namely childrens' anxiety about science as related to their teacher's anxiety, and found no relationship. Yurkowicz (1988) reports students perception of teacher behaviors is related to pupil science anxiety. Both researchers used the STAI to measure teacher anxiety but did not use the same title and did not use the same measures for children's anxiety. These studies point out the need for continued investigation of this question.

VIII. Conclusions

What began as an attempt to understand why teacher appear frightened of science has evolved into a long term commitment to repeat and re-examine old studies, discover related variables and try to understand the relationships among these variables in cooperation with other researchers. As more research studies begin to create a clearer picture of factors associated with learning science the need for a "model" or comprehensive theory becomes apparent.

Returning to our initial analogy of the problems of earthquake prediction, Parker (1985) proposed a model for geologist. His proposes that the earth has natural energy reservoirs (buffers) which, when filled to capacity by the continuous supply of energy from within the earth and from the sun, periodically release energy producing earthquakes. The tempo of geologic events is a function of the rate of energy input and the ability of the buffer to store energy. This "model" explains the mode and temp of geologic events but it will be some time before geologist can isolate and quantify energy input and fully accurately describe all buffers. Proposing a theory is essential one step, putting numbers on it another!

What theory or framework can we devise to understand how anxiety and related variables affect learning in science? Certainly achievement is related to anxiety reduction. Achievement, or success also is related to being in control (self-efficacy), and to confidence.

Czerniak and Chiarelott (1990) review the research between teachers' self efficacy, anxiety and teaching effectiveness and provide a social cognitive model for understanding reasons for understanding science instruction and for developing teacher educational practices for effective science instruction.

Psychologists can formulate a model for understanding cognitive and emotional factors which explain how one learns science. Using this model science educators may be able to bring about change in the learning environment which will generate successful learners. Success in learning science for the non-science student as well as the science student may have benefits for the individual that go beyond obtaining knowledge (i.e. increased self confidence).

Science educators are concerned about how, and under what conditions, science learning occurs for all people and if differences exist between females and males. If so, when and why do gender differences appear? Do age groups and ethnic and socio-economic groups differ? What can be done to close and present gender gaps?

Caution must be taken not to "lump" all females and males. Czerniak and Chairelott (1990), report that "in general, the findings indicate that females experience more science anxiety, have more negative attitudes toward learning science, and perform more poorly in science than males." p. 52. Westerback, (1986); Westerback, Primavera and Gonzalez, 1984: and Davis 1987 did not find this true for college students. Westerback (1986) found

females taking biology and psychology courses more anxious than females in physical sciences. However, this was only one sample in one academic year. Much more data needs to be examined.

We also need to consider the time period the studies were done. In 1977 Westerback did not find the number or enjoyment of science content courses related to anxiety about teaching science. In the 1980's Czerniak found a relationship between content courses, success and anxiety. It is reasonable to believe that the type of instruction these two groups experienced in high school and/or college could be different.

The effects of anxiety on teacher behaviors in the classroom and children's anxiety levels is important. Changing teacher behaviors so that science students can be successful, confident and self-efficacious is certainly an important goal.

Finding solutions requires being tenacious and not easily discouraged, developing support and communication among researchers, repeating and/or redesigning studies, and conducting long term studies with many different groups so that a large reliable data base will be established.

The need to "hang in there" is shown by Westerback's initial study done in 1977-1978. At the end of one semester attitude was changed in a positive direction but anxiety was not significantly reduced during the first semester. If the study had not been done over an entire academic year, and repeated for several years the patterns of anxiety reduction reported in the literature would not be evident.

Consistent results and refined studies should ultimately provide insights and solutions to our questions. Hopefully it will be faster than earthquake research!

References

Campbell, J. R. (1992). The socio-psychological piano -- the differential socialization metaphor: Applications across ethnic groups and countries. Unpublished manuscript.

Campbell, J. (1992). "The socio-psychological piano: A metaphor for understanding gender and minority differences." Paper presented at the National Association for Research in Science Teaching, Boston, MA.

Campbell, J., (1991). "The roots of gender inequity in technical areas." Journal of Research in Science Teachings, 28 (3), 251-264.

Campbell, J., and Bawdry, J. (1992). "Differential socialization implicated for high achieving 11th-grade math students". Paper presented at the American Educational Research Association, national meeting, San Francisco, CA.

Czerniak, C. (1992). "A qualitative comparison of elementary preservice teachers identified as high and low anxious about teaching science". Paper presented at the National Association of Research in science Beaching, Boston, MA.

Czerniak, C. (1990). "Teacher education for effective science instruction - A social cognitive perspective". Journal of Teacher Education, (41) 1, 49-58.

Czerniak, C. (1989). "An investigation of the relationships among science teaching anxiety, self-efficacy, teacher education variables, and instructional strategies", Paper presented at National Association of Research in Science Teaching, San Francisco, Ca.

Czerniak, C. & Chiarelott, L. (1985). "Science anxiety among elementary school students: Equity issues", Journal of Educational Equity and Leadership, 5(4), 291-308.

Chiarelott, L. & Czerniak, C. (1986, March). "Science anxiety among elementary and junior high students and their teachers", Paper presented at National Science Teachers Association, San Francisco, Ca.

Davis, G. (1987) "Measuring the science anxiety of college students in an introductory chemistry course." paper for National meeting of the American Educational Research Association, Washington, D. C.

Dreger, R.M. (1978). State anxiety inventory. In O. Buros (Ed.), The eight mental measurement yearbook (pp. 1094-

1095).

Goldsmith, J. (1986). "The effect of an activity based model toward the reduction of science teaching anxiety in pre-service elementary science teachers". Paper presented at the American Educational Research Association, Washington, D.C.

Good, R. (1992). "Editorial - The importance of replication studies". Journal of Research in Science Teaching, (29) 3, 209.

Parker, R. (June 1985). "Buffers, energy storage, and the mode and tempo of geologic events". Geology, (13), 440-442

Sherwood, R. D., & Westerback, M.E. (1983). "A factor analytic study of the state-trait anxiety inventory utilized with preservice elementary teachers", Journal of Research in Science Teaching, 20(3), 225-229.

Spielberger, C. D., (1985) Assessment of sate and trait anxiety: Conceptual and methodological issues. The Southern Psychologist, 2, 6-16.

Spielberger, C.D., (1970). STAI Manual for the State-Trait Anxiety Inventory. Palo Alto, CA: Consulting Psychologist's

Press.

Spielberger, C.D., in collaboration with Gorsuch, R.L., Lushene, R., Vagg P.R. & Jacobs, G.A. (1983). Manual for the State-Trait Anxiety Inventory STAI (Form Y), Palo Alto, CA: Consulting Psychologist's Press.

Westerback, M. E. (1982). "Studies on attitude toward teaching science and anxiety about teaching science in preservice elementary teachers. Journal of Research in Science Teaching, 19(7), 603-616.

Westerback, M. E. (1984). "Studies on anxiety about teaching science in preservice elementary teachers. Journal of Research in Science Teaching, 21(9), 937-950.

Westerback, M. E. (1986). "Anxiety levels of college students taking required science courses". Paper presented at the National Association for Research in Science Teaching Association, San Francisco, Ca.

Westerback, M.E., Gonzalez, C. & Primavera, L.H. (1984). "Comparison of anxiety levels of students in introductory earth science and geology courses", Journal of Research in Science Teaching, 21(9), 913-929.

Westerback, M.E., Gonzalez, C. & Primavera, L. H. (1985). "Comparison of preservice elementary teachers anxiety about teaching students to identify minerals and rocks and students in geology courses anxiety about identification of minerals and rocks", Journal of Research in Science Teaching, 22(1), 63-79.

Westerback, M.E., & Long, M. E. (1990). "Science knowledge and the reduction of anxiety about teaching earth science in exemplary teachers as measured by the Science Teaching State-Trait Anxiety Inventory". School Science and Mathematics, 90(5), 361-374.

Westerback, M.E. & Primavera, L. H. (1992, unpublished). The relationship between state anxiety and confidence in mathematics and confidence in science using the SaaS.

Westerback, M.E., & Primavera, L. H. (1988). "Anxiety about science and science teaching" in Advances in Personality assessment, Spielberger, C. D. & Butcher, J. N. editors, Lawrence Erlbaum Associates: Hillsdate, New Jersey, 175-202.

Yurkewicz, W. (1988). "The relationship among teacher behaviors, science anxiety, and success in science". Unpublished doctoral dissertation, State University of New York at Albany, N.Y.

Zoller, U. & Ben-Chaim. (1988) "Interaction between examination type, anxiety state, and academic achievement in college science: an action-oriented research", Journal of Research in Science Teaching (26)1, 65-77.